IX. *On the Structure of Chitons.* *By* J. E. Gray, *Esq.*, *F.R.S.*, *F.Z.S.*, &c.

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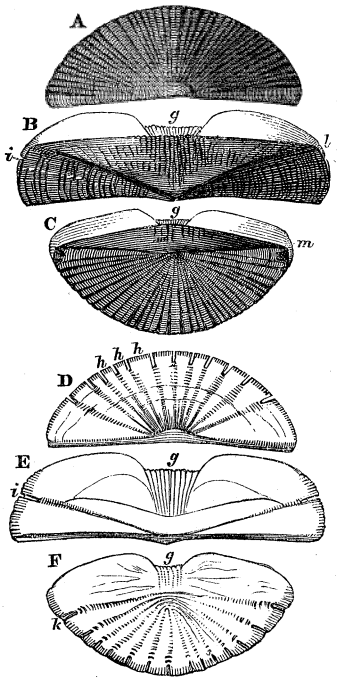
Linnæus and most of his successors arranged the *Chitons* with the *Pholades* and the *Balani*, as multivalve shells. Adanson, with his usual tact, placed them with the *Patellæ*, and the anatomy of the animal, published by Poli and Cuvier, has shown the propriety of this position. M. de Blainville separated the Chitons from the other Mollusca, with which they had always been placed on account of their possessing a series of imbricated shelly valves arranged along the central line of their back, and placed them with the *Cirripedes* in a peculiar subclass, which he called Articulated Mollusca, and considered as intermediate between the two divisions of the animal kingdom. I need scarcely observe that this division has not been adopted, the Cirripedes having now been proved to be true Crustacea.

There are a few peculiarities in the internal structure of these animals not found in other Mollusca. The shells also offer some differences, which have not, as far as I am aware, been previously noticed, and which it is the object of this paper to describe.

The *Chitons* at first sight differ from all the other Mollusca in being provided with a series of imbricated valves, forming a line down the centre of the back, and in this character they differ essentially from the *Patellæ*, to which they are most nearly allied in the general form, the position of the gills, &c. I have therefore thought it desirable to examine these valves with reference to one another, and to determine which most resemble the valves usually found on other Mollusca, and which are the additional or supplementary valves.

Fig. 1.



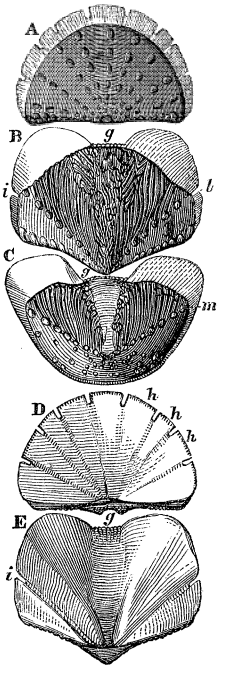
Chiton striatus.

The posterior terminal valve (fig. 1, C and F, fig. 2, C) of the more normal *Chitons*, as in the restricted genus *Chiton* for example, most nearly resembles the conical form which the valves of Mollusca generally assume, and the other valves are only modifications of the same form.

The seven anterior valves are formed like the posterior one, but with the greater part of the hinder half deficient, and with the front edge of insertion somewhat enlarged. In the front valve (figs. 1 and 2, A and D) the anterior

wings of insertion found fully developed in the intermediate valves (figs. 1 and 2, B and E) are reduced, and the teeth (figs. 1 and 2, *g*), which are generally to be seen in the middle portion of the front edge of the posterior and intermediate valves between the wings of insertion, are greatly enlarged, forming an uniform edge extending along the entire outer and anterior boundary of the valve.

Fig. 2.



Enoplochiton niger.

The lobes on the margin of the front valve are generally to be seen distinctly developed, but of a smaller size on the front edge of the central portion of the posterior and medial valves (figs. 1 and 2, *g*); and they are generally most developed on the valve next to the front one; from the notches (figs. 1 and 2, *h*) between these lobes in the edge of the front valve, there issue series of pores; and similar series of pores, but more crowded and interrupted, are to be observed in the middle of the inner surface of the intermediate valves (figs. 1 and 2, *g*), showing the truth of this comparison. The notch (figs. 1 and 2, *i*) on the hinder part of each wing of insertion of the intermediate valves is evidently the same as the front notch on the edge of insertion of the hinder valve (fig. 1, *k*); the raised edges (figs. 1 and 2, *l*) on the medial valves which separate the front of the valves into what has been called the lateral and central area, are analogous to the more or less distinct keel (figs. 1 and 2, *m*) which passes from the apex to the front edge of the margin of the hinder valve.

In the more abnormal *Chitons*, as in the genus *Katharina*, which have the apex of the posterior valves lower down, and produced beyond the margin, arising from the hinder portion of the posterior valve being more or less abortive, while the front portion is more than usually developed, the hinder valve loses its peculiar character and more nearly resembles the usual form of the intermediate valves, and the posterior edge of the hinder valve has only a small simply striated or smooth edge of insertion in the place of the lobed plates of insertion of the other genera.

The result of this examination of the structure of the valves of the *Chitonidæ* is exactly what we might have expected *à priori*, though it has not, that I am aware, been observed by any preceding author, and did not occur to me until after the comparison of the valves with one another. That is to say, the posterior valve which is placed over the more important organs is generally the most fully developed, and is the homologue of the shell of the *Patella*, while the others which are arranged in front of it are more imperfect, and the front one is the most rudimentary of the series. The *Chitons* may therefore be considered as normal Gasteropodes, with a series of more or less rudimentary valves in front of the usual shell. These additional valves appear to have no relation to the second lateral valve found in the normal or bivalve *Mollusca*, or to its representative in the Gasteropodes, where in some genera

it assumes the form of an operculum, but is, as in the *Chitons*, often wanting, especially in the adult state.

Besides having this multiplication of the valves, the parts of the cartilaginous mantle not covered by the valves are generally more or less closely covered with calcareous scales or subcylindrical spines, which sometimes are so fine as to assume the form of more or less flexible bristles or hairs. I cannot call to mind any mollusca which are protected in a similar manner; the scales and bristles more resemble those on the peduncles of certain Cirripedes belonging to the family *Pollicipedidæ*, and must be regarded, as the scales are in those genera, as rudimentary valves; their form and disposition afford very good zoological characters for the distinction of the species. In some, as in the *Chiton amiculatus*, where the valves are hidden, these spines are nearly transparent, and resemble *spicula*. In others, on each side of the mantle, there is a symmetrical series of pores, each armed with a tuft of spicula. The spicula may be only modifications of the spines which are found on the surface of the mantle in the other species; but this is a subject worthy of more minute inquiry, and I am not aware of any similar spicula being found in any other molluscous genus, unless they are to be compared to the spicula which are to be found imbedded in the mantle of *Phyllidia*, an allied genus; but the latter are more like the spicula of Radiata and Sponges.

The valves of those kinds (as of *Chiton amiculatus* of Pallas) which are entirely imbedded in the mantle and hidden from external view, are formed much like the valves of other mollusca, of numerous layers of calcareous matter, and they increase in size by the addition of new material deposited on the inner edge. Their structure is compact, hard, heavy and very brittle, and the calcareous matter takes the form of crowded perpendicular laminæ, placed side by side, diverging from the apex towards the edge. As the animal increases in size, these valves are thickened by the addition of numerous layers of hard shelly matter, deposited on the inner side, forming a hard, glassy concretion.

But the greater number of species have a part of the valve which is not covered by the mantle, but exposed. This exposed part consists of a perfectly distinct external coat, peculiar I believe to the shells of this family. The outer coat of these valves is separated from the lower or normal portion by a small space, filled by a cellular calcareous deposit, which is easily seen in a section of the valves, and also on the edge of the valves, occupying the space between the inner and outer plate of insertion, where it looks like a series of circular holes or tubes; the space between these coats and the cellular internal layer enlarges in thickness and length as the valves increase in size and thickness.

This cellular or tubular structure, as the shell increases in size, also fills up, as far as the margin of the outer coat, the notches on the edge of the inner coat which separate into lobes the inner part of the valves which are inserted into the cartilaginous mantle. The filling up of these fissures with this porous matter is peculiar to

this family; for the fissures on the margin of the shells of the genus *Emarginula*, of *Pleurotoma*, of *Pleurotomaria*, and of the holes formed by the notches in the edge of the lip of *Haliotis*, are filled up by layers of shelly matter of the same structure as the rest of the shell, and deposited in the same manner. These fissures, filled with this porous substance, may be seen on the inner surface of the valves forming lines of pores diverging from the tip, and increasing in width as they approach the edge, to the notches above referred to: they are useful in a zoological point of view, as showing the number of lobes into which the inner plate of insertion is divided.

The valves of the species whose shells are covered by the mantle have a plain edge, with only one or two notches.

Those of which the shells are partly external have the inner coat of the valve produced beyond the outer coat, thus forming what is called the plate of insertion; for the valves of these animals do not simply cover the mantle as with a case, but have their edge inserted into the cartilaginous mantle, another character peculiar to this group.

The inner plate of insertion, besides being divided into lobes by the fissures or slits above mentioned, has the edges of the lobes divided into deep grooves or pectinations.

The edge of the outer coat, which is never slit or lobed, is similarly but not so strongly pectinately divided, where it is inserted into the mantle.

This kind of edge is probably produced by the perpendicular radiating laminæ of which the two coats are formed, the number of teeth appearing to agree with the number and thickness of the plates, the teeth and laminæ being thicker and more numerous on the outer than on the inner coat.

This kind of edge does not occur, as far as my observation extends, in any other mollusca, for it is very unlike the grooves on the edge of many bivalves which are formed by the processes on the surface of the mantle, and more resembles the plates between the tubes in the substance of the valves of some Barnacles (*Balani*), but has no real resemblance to them in structure.

The more prominent peculiarities of this family appear to be,—

1. That instead of having a single valve, as is the case with most Gasteropodes, they have a series of more or less perfect valves placed in front of the normal valve, the front one being the most imperfect, all imbricated the one over the other.

2. Besides this increase in the number of valves, the surface of the mantle is covered with numerous rudimentary valves assuming the form of scales or spines.

3. These spines are sometimes placed in tufts symmetrically dispersed on the sides of the body.

4. The valves of the more normal *Chitons*, which are partly exposed, are furnished with two additional coats, of the size of the exposed part, not found in the shells of any other mollusca, the intermediate coat being of a porous texture; and this coat fills up the symmetrical slits usually found in the innermost coat.

5. The valves of these shells, instead of being simply placed on the surface of the mantle and attached to the animal by muscles, are inserted by their edge into the substance of the cartilaginous mantle.

Hence we may conclude, that though it is impossible to adopt M. DE BLAINVILLE's views with regard to the systematic arrangement of *Chitons*, yet they offer many particulars not found in other mollusca; and that in the structure of the edge of the valves, where they are inserted into the mantle, and in the formation of the central cellular coat, which is doubtless formed by small processes of the mantle, like the tubes in the substance of the valves of the coronal Cirripedes, they offer an analogy to the shells of those Crustacea which has not before been observed.